

RADIATIVE TRANSFER EFFECTS OF STRATOSPHERIC AEROSOLS AS A FUNCTION OF TIME

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1. INTRODUCTION

The eruption of Mount Pinatubo in 1991 created a large number of stratospheric aerosols that are generally believed to have a climatic effect. Whether the climatic impact is one of warming or cooling the troposphere depends critically on the size of the particles. In general, smaller particles tend to cool the troposphere while larger particles will warm the troposphere. This paper discusses the effect of the Pinatubo aerosol on the net radiative fluxes with time.

Sunphotometer measurements of optical depth at different wavelengths are utilized to calculate mode radius and the standard deviation of the stratospheric aerosol (assuming a log-normal distribution). The optical depth measurements were made over the period before and after the eruption of Mt. Pinatubo. The aerosol optical depths are largest about two months after the eruption and then start to decline, while the effective radius continues to increase (presumably due to coagulation). Net flux calculations show a global cooling for the troposphere and the earth-atmosphere system.

2. PARTICLE SIZE AS A FUNCTION OF TIME

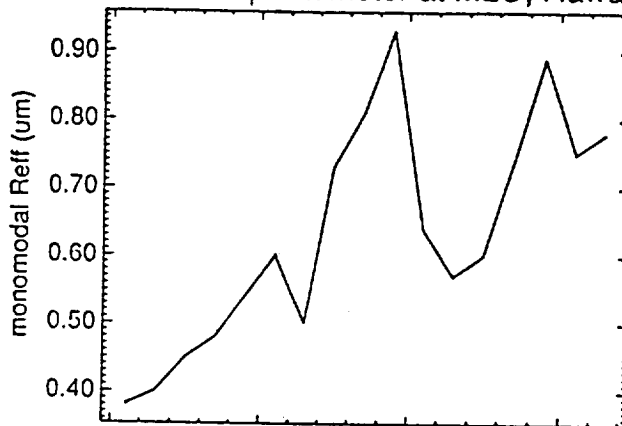
The eruption of Mt. Pinatubo sent a large amount of both gases and particles into the stratosphere. Initially, the size distribution of the particles was quite variable with relatively large numbers of both small ($r < 0.25 \times 10^{-6}$ m) and large ($r > 1 \times 10^{-6}$ m).

As the volcanic cloud aged, the larger particles settled out and the gases formed smaller particles that coagulated and grew. The result was that the size distributions became progressively more stable and narrower with mode radii about 0.7×10^{-6} m.

To determine the change in the mode radius and standard deviation of the aerosol, we took the data for monthly averaged sunphotometer optical depth measurements at MLO, Hawaii (Dutton, E. G. et al., 1993). The results are shown in Figure 1.

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NOAA sunphotometer at MLO, Hawaii



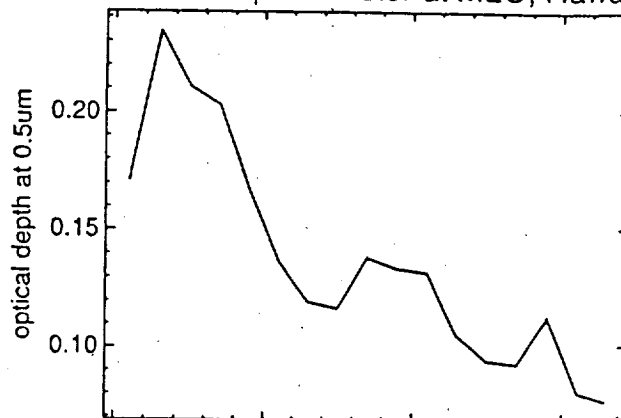
July 1991 - November 1992

As shown, the effective radius, Re , increases steadily in the time after the eruption.

3. RADIATIVE TRANSFER EFFECTS

The NOAA data from MLO for optical depth is shown in Figure 2.

NOAA sunphotometer at MLO, Hawaii



July 1991 - November 1992

As shown, the optical depth increases initially and then slowly starts to fall.

Using these data, we have estimated the net flux changes at the tropopause and the top of the atmosphere. We have used a two-stream model with eight bands in the solar and twelve in the infrared. The calculations include the effect of a summer hemisphere and a winter hemisphere. The fraction of total cloud cover for high, middle and low clouds were taken from a 3DNEPH cloud climatology (Koenig, et al., 1987).

The Pinatubo aerosol is assumed to be 75% sulfuric acid droplets with the size and optical depth presented above. The results are shown below:

Flux changes at the Tropopause (W/m²) Time after eruption

	Solar	IR	Net
3 months	-3.2	0.6	-1.8
1 year	-3.6	0.7	-2.1

Flux changes at Top of Atmosphere (W/m²) Time after eruption

	Solar	IR	Net
3 months	-3.1	1.9	-1.2
1 year	-3.4	2.1	-1.3

The calculations suggest a global Pinatubo cooling of about -2W/m² for the troposphere and about a -W/m² for the earth atmosphere system. The calculations indicate that the cooling remained approximately constant over the first year.

4. REFERENCES

- Dutton, E. G., P. Reddy, S. Ryan, and J. DeLuisi, 1993: Spectral aerosol optical depth observed at mauna loa, hawaii: 1982-1992. Submitted to *JGR*
- Koenig, G. G., K.N. Liou, and M. Griffin, 1987: An investigation of cloud/radiation interactions using three-dimensional nephanalysis and earth radiation budget data bases. *J. Geophys. Res.*, 92, 5540-5554